MODIS Snow Project
Quarterly Report (Jan.-Mar. 1995)
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Summary

Research progress has been made in several areas during the last 3 months, and plans have been finalized for the April aircraft mission in Alaska. One presentation has been made and 2 papers and 2 abstracts have been submitted for publication.

Research Progress

Sea Ice Algorithm Development. Work has been progressing in developing the MODIS sea ice mapping algorithm. Several new TM scenes have been acquired and the algorithm has been run on the scenes. The algorithm has successfully mapped sea ice, water and most clouds. Cirrus clouds are still a problem and are not consistently being separated from sea ice. Collaboration with Dr. Ron Welch of the South Dakota School of Mines and Technology has been fruitful. Very shortly we will undertake a comparison of the results obtained by Dr. Welch with our results. This may help us to determine the errors of our method of mapping sea ice.

Co-Meas Conference. In preparation for the Combined Optical-Microwave Earth and Atmosphere Sensing conference to be held in April 1995, we have obtained several data sets and registered AVHRR and SMMR or SSMI data to the AVHRR data (see Appendix I). This is being done in order to map the data to a common grid so that comparsons between data sets will be meaningful. We have collaborated with the NSIDC at the University of Colorado in order to locate and grid the AVHRR and SSMI data. A sample time period has been prepared. The sample shows that gridding the AVHRR Pathfinder and SSMI data to NSIDC's EASE-Grid can be done successfully. The drawback to doing that in an automated way is that the AVHRR sensor does not have the proper channels for snow/cloud separation and thus is not suitable for mapping snow without human intervention.

Also in connection with the April conference, we obtained AVHRR data from EDC in Sioux Falls, SD. However, the scenes were too cloudy to be of use and were not gridded.

Gridded AVHRR data from 15 May 1994 were obtained of Alaska from the Alaska SAR Facility in Fairbanks. These data were mosaicked and registered with gridded SSMI data. An excellent comparison was made which showed a distinct snowline on the North Slope of Alaska on both the AVHRR and SSMI data. Unfortunately, snow in the Alaska Range was not mapped by the SSMI snow-mapping algorithm because of melting in the Alaska Range in mid-May. The wet snow had a microwave brightness temperature that was similar to the surrounding terrain and was thus not mapped as snow.

MODIS Airborne Simulator (MAS) BOREAS Data. Other research progress was made in the analysis of the MODIS Airborne Simulator data acquired of the southern BOREAS test site in Canada in February of 1994. The only 2 good MAS scenes were registered to the TM scene, which was acquired 2 days after the MAS data were acquired. We are now in the process of applying the 6S atmospheric correction program to the TM and MAS data so that we can run the SNOMAP algorithm.

Passive-Microwave Algorithm Development. Jim Foster, in connection with his Ph.D. research, is continuing to develop passive-microwave algorithms to determine global snow depth. The matter of the shape of snow grains and how shape affects microwave emission and scattering has only been dealt with in a cursory manner. Current algorithms assume that all the grains are spherical and do not account for irregularly-shaped snow grains. Even when depth hoar crystals have been modeled, spherical grains are used with a diameter approaching the longest length scale of the depth hoar crystal. The myriad of possible shapes and sizes encountered in a snowpack makes modeling the radiative transfer an especially arduous task. The microwave algorithm that we have developed and refined, mimics the snowpack as a single layer having spherical snow grains of 0.3 mm radiuus for all land areas, except the continental interiors (boreal forest areas) where larger grain sizes are prescribed. Additionally, in boreal forest areas the effect of the vegetation on the microwave signal is considered by using a forest cover parameter derived from an albedo index.

Spectral-mixture modeling. Dr. Anne Nolin, under contract to NASA for this project, has run a spectral mixture model on the 14 March 1991 TM image of Glacier National Park. This is a scene that we have previously classified using SNOMAP. Her results show that SNOMAP mapped about 4.2 percent more snow than was mapped by the spectral mixture model technique. It is believed that the SNOMAP results are more accurate because simultaneous ground truth showed that there was a complete snow cover on 14 March.

Aircraft Mission in Alaska

The overall objective of this mission is to acquire remotely-sensed measurements of snow and sea ice to permit the development of improved algorithms for mapping snow and sea ice cover, snow thickness and sea ice concentration, using satellite data. Airborne and ground-based measurements will be acquired simultaneously, when possible, over many of the snow sites.

The aircraft experiment will be conducted with the NASA ER-2 from Ames during a 3-week period beginning 1 April 1995. Passive microwave and optical and IR sensors as well as an aerial camera will be on board. Satellite data from the DMSP SSMI, the NOAA AVHRR, ERS-1 and JERS-1 will also be acquired.

This work is being done in collaboration with the University of Alaska (Dr. Carl Benson) and the U.S. Army Cold

Regions Research and Engineering Laboratory (CRREL) (Dr. Matthew Sturm). Results from the field and aircraft measurements will be analyzed jointly among scientists at Goddard, the University of Alaska and CRREL.

Papers and Presentations

Papers:

Salomonson, V.V., D.K. Hall and J.Y.L. Chien, "Use of passive microwave and optical data for large-scale snow-cover mapping," to be published in the Proceedings of the Combined Optical and Microwave Earth and Atmosphere Sensing conference to be held 3-6 April, 1995. **(Appendix I)**

Hall, D.K., G.A. Riggs and V.V. Salomonson, "Development of methods and analysis of errors for mapping snow cover using Moderate Resolution Imaging Radiometer (MODIS) data," Remote Sensing of Environment (submitted). **(Available on Request)**

Riggs, G.A., D.K. Hall and V.V. Salomonson, "Algorithms for global snow and sea ice mapping with the Moderate Resolution Imaging Spectroradiometer (MODIS,", submitted for publication as an abstract in EOS, supplement for spring AGU meeting. **(Appendix II)**

Hall, D.K., J.L. Foster, A.T.C. Chang and K.S. Brown, "Mapping snow cover during the BOREAS winter experiment," abstract accepted for presentation at the Eastern Snow Conference to be held 7-8 June 1995 in Toronto, Canada; paper is in preparation for the proceedings. **(Appendix III)**

Presentation:

D. K. Hall presented an invited seminar to the Potomac Geophysical Society entitled, "Remote sensing of global snow cover and glaciers for climate-change studies," 19 January 1995, Wash., D.C.